
Primary Beam Performance



Minos Collaboration Meeting 3/18/2005

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Outline

- Measuring POT
- Beam stability: width and emittance
- Beam stability: losses
- Beam stability: position
- Beam position: profile monitors vs BPM
- Beam position: target vs pretarget
- Correlating beam and ND data

	Q1D1	44.4
	BPM-V	58.4
	BPM-H	59.3
	Profile Monitor	65.0
	Res. Wall Mon.	
	Toroid	65.6

	BPM-H	1142.2
	BPM-V	1143.1
	Profile Monitor	1143.9
	Toroid	1182.1
	BPM-H	1183.1
	BPM-V	1184.0
	Profile Monitor	1184.8
	OTR	
	Baffle	1207.3
	Target	1214.4
	Hom 1	1215.6
	Hom 2	1248.2
	Absorber	3586.7

POT Measurement Status

Two toroids, located at either end of the beamline, measure absolute intensity: 101 and TGT.

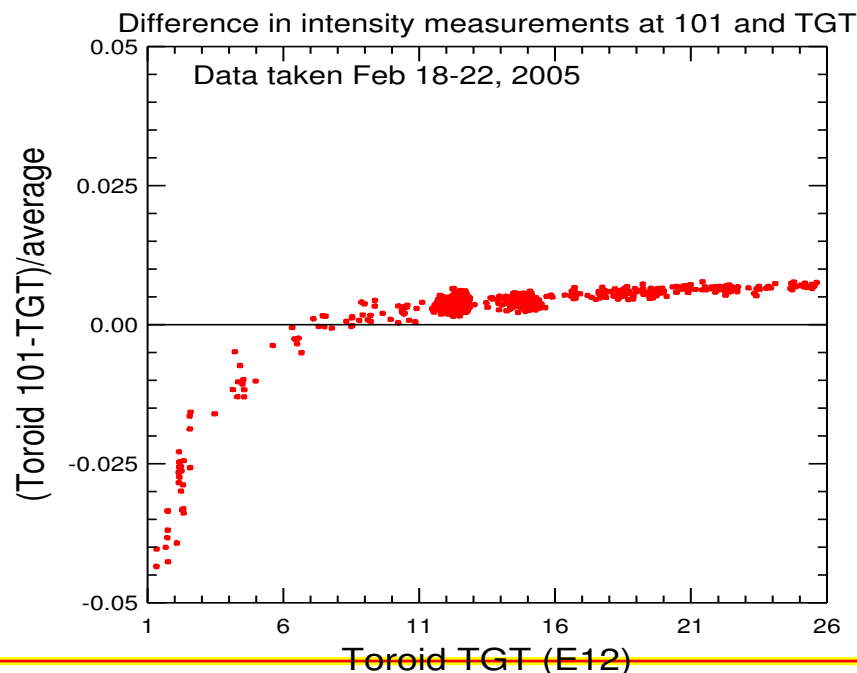
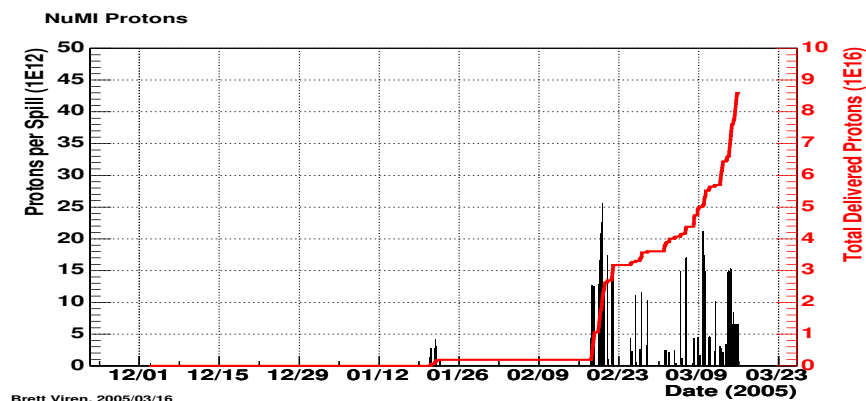
- Discrepancies in measurements of proton intensity at 101 and TGT.

Feb 25-Mar 14, 2005:

$$TotPOT_{TGT} = 3.2244 \times 10^{16}$$

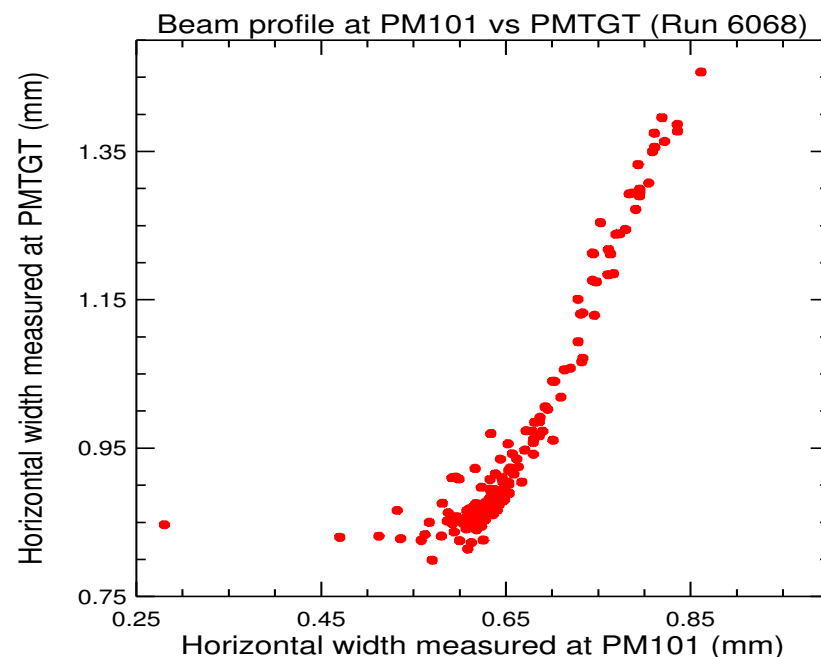
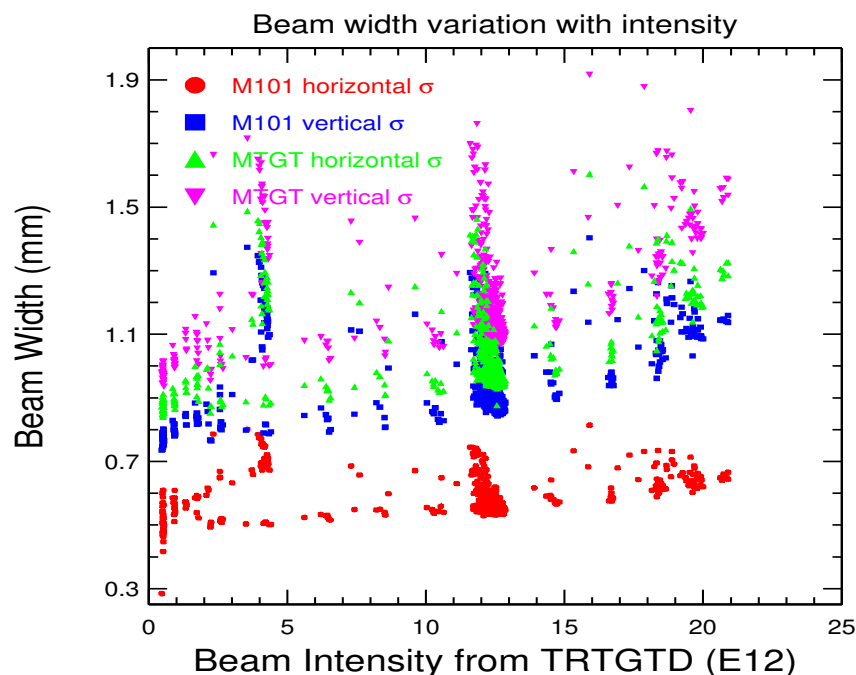
$$TotPOT_{101} = 3.2799 \times 10^{16}$$

- Timing problems recording toroid readouts and loss of beam data due to computer downtime. \Rightarrow uncertainty ?



Beam width stability

- The beam width specifications are 1 mm in the horizontal and the vertical. At 2.5 E13, its 1.3 and 1.6 mm respectively.
- Extracted beam width is not stable (bad booster beam?). Variation is large, almost 60%. We need to include these variations in MC studies of beam systematics.

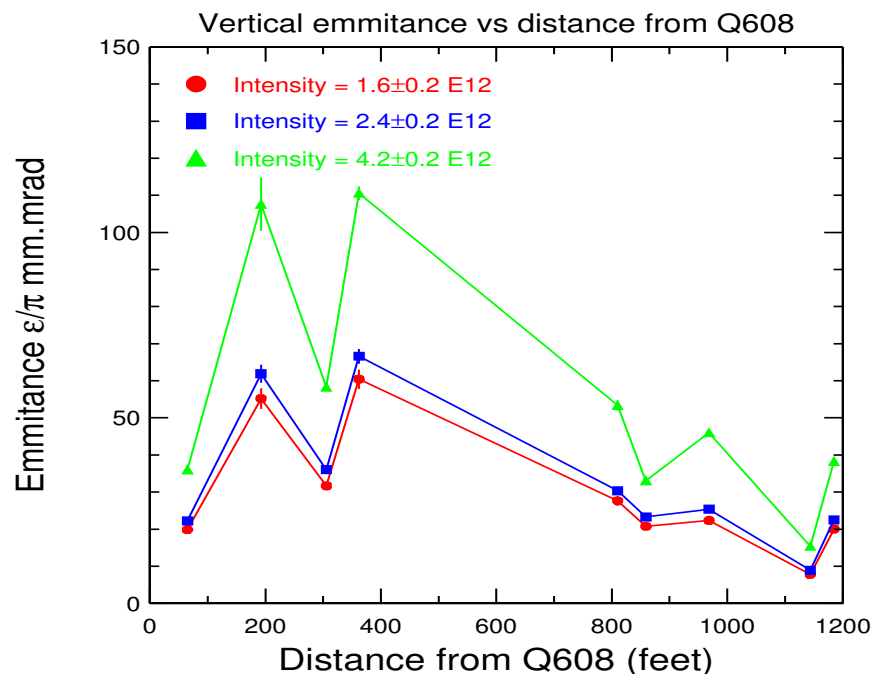
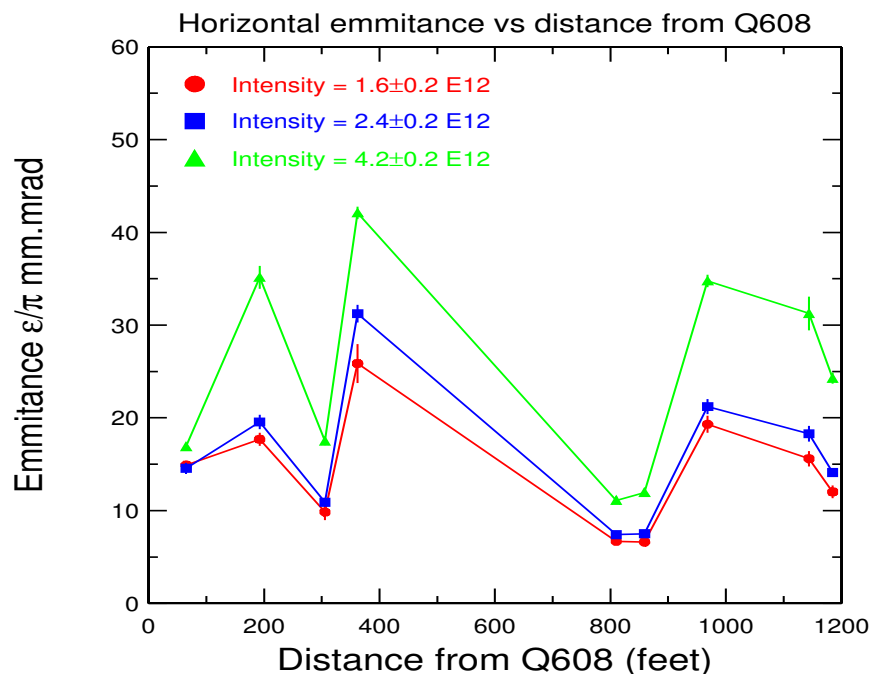


Beam emittance

Beam emittance is the invariant quantity not beam profile:

$$\epsilon/\pi = 767.4 \times \sigma^2/\beta$$

where β is calculated at each profile monitor location and σ is the profile measured using the profile monitors.

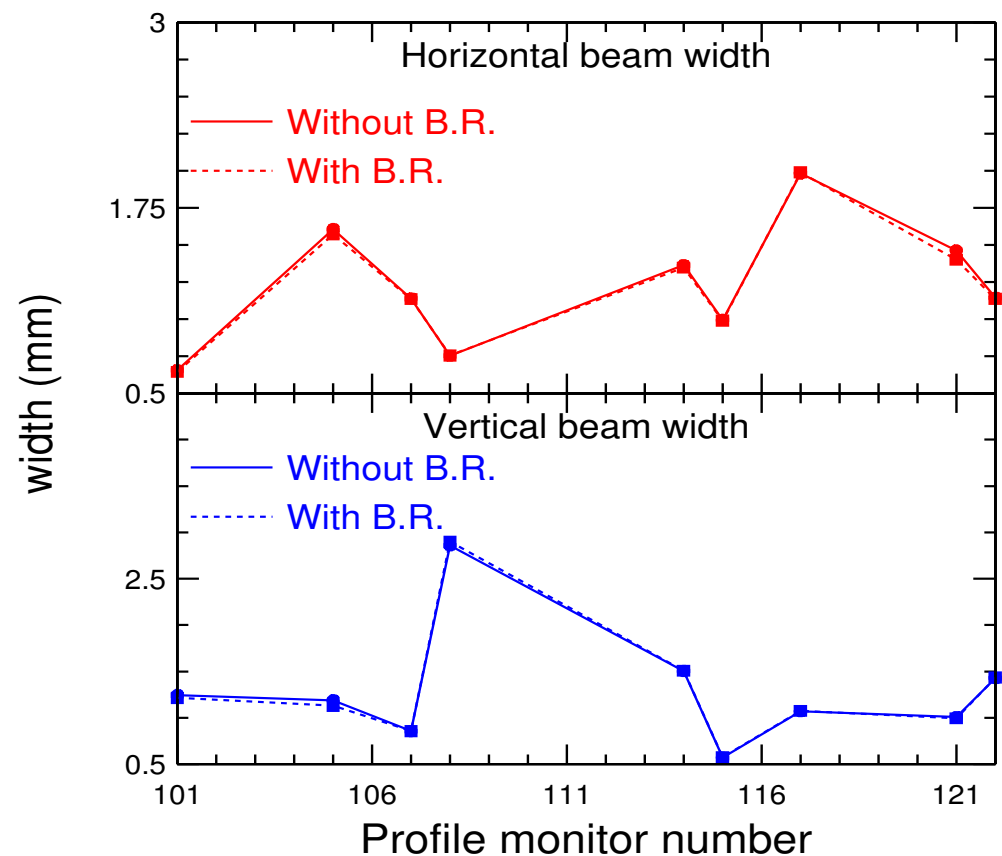


We do not understand the beam optics yet. P. Lucas 3/17/2005:
“We just found out Q101 is running 40% low”.

Beam emittance & bunch rotation

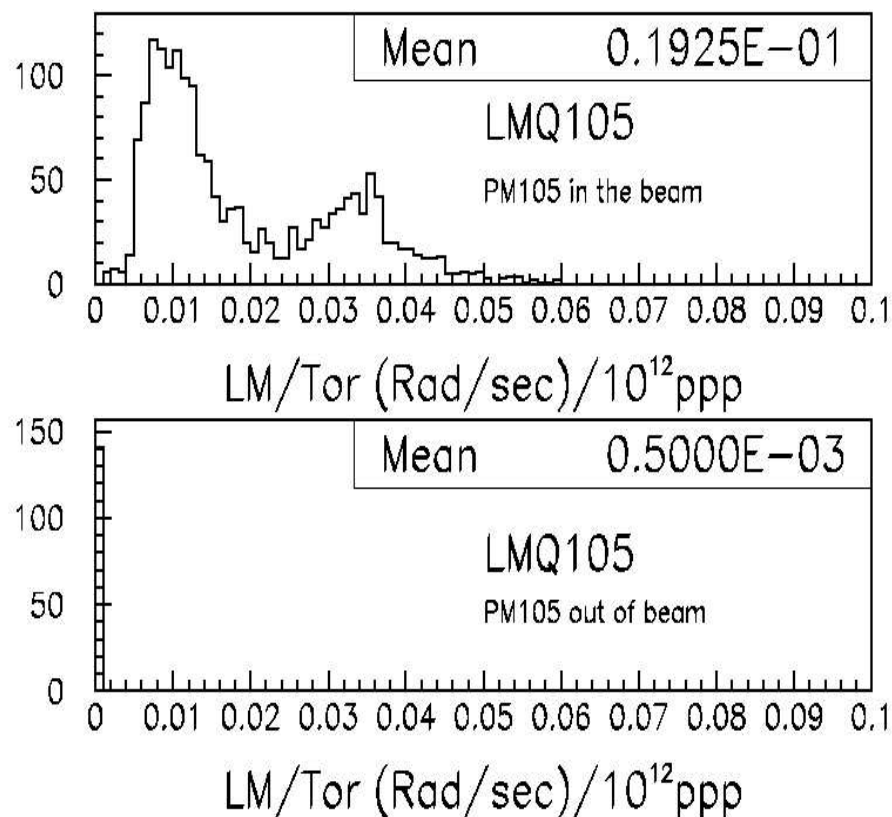
Could the large variation in emittance along the beamline be due to large $\Delta(p)/p$? This would cause larger transverse emittance at points of high dispersion.

- B.R. is a technique to narrow the bunch length of the beam sent to \bar{p} .
- Smaller bunch length \Rightarrow larger $\Delta(p)/p$
- B.R. studies show no change in beam width $\Rightarrow \Delta(p)/p$ is small in NuMI.



Beam stability: losses

The profile monitors are used to measure the beam profiles, but PMs (5 μm Ti foil) induce the largest losses. How much?

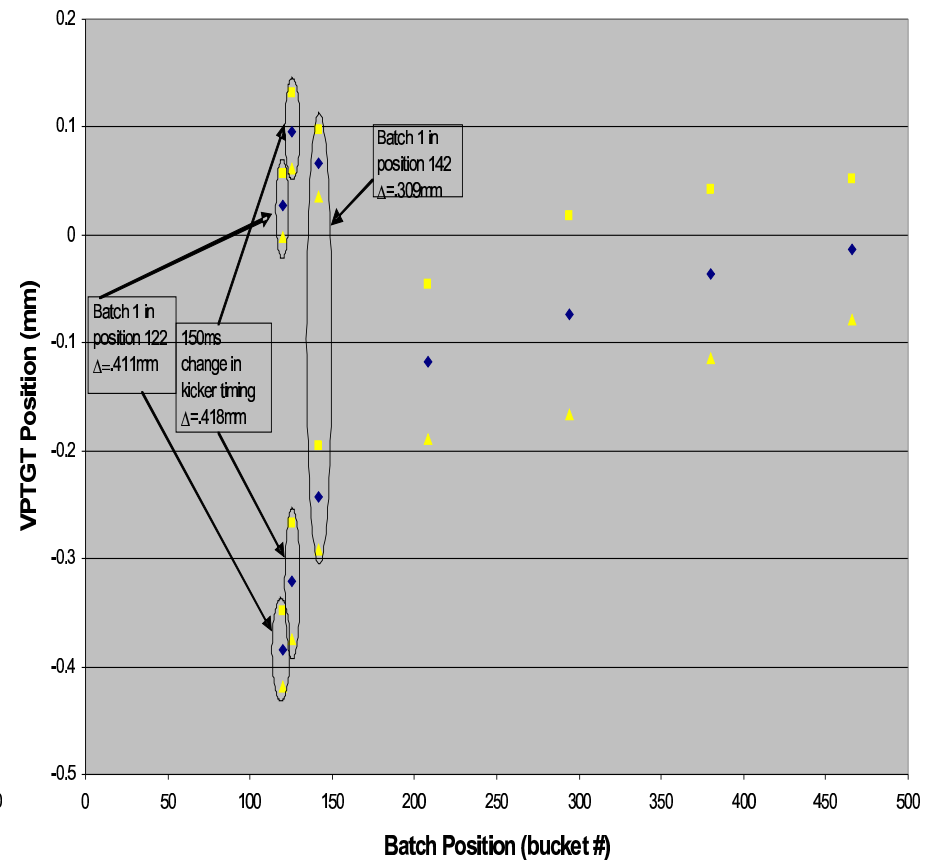
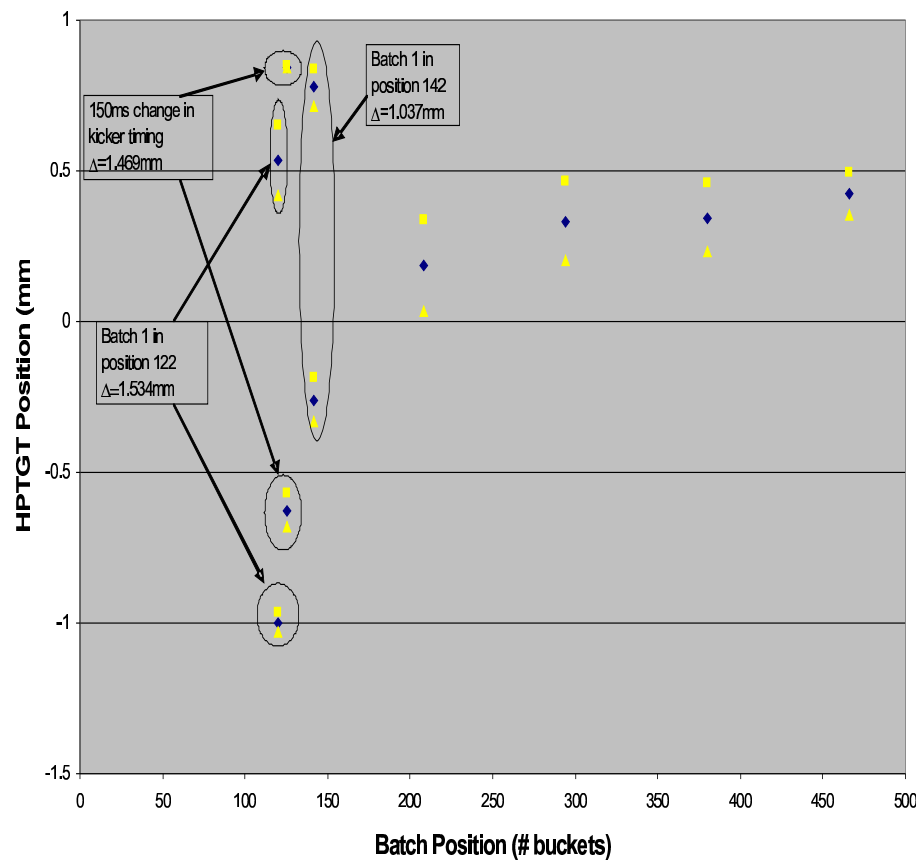


Profile Monitor	Loss Monitor	Loss when PM 'in' ‡ (Rad/sec)/10 ¹² ppp	Loss when PM 'out' (Rad/sec)/10 ¹² ppp
101	101	2.1E-4	1.2E-4
	102	3E-4	1.1E-4
	104	2.1E-4	1.2E-4
105	105	0.019	3E-3
	107	0.014	5E-3
	109	0.005	5E-4
107	107	0.0141 (0.008)	1.6E-4
	109	4.7E-4 (1.2E-4)	5.2E-5
108	108	0.017 (0.007)	0.01 (2.5E-4)
	109	4.8E-4 (9E-5)	1.7E-4 (0.007)
112	112	1.9E-3 (3.5E-4)	1.2E-3 (8.2E-4)
	113	0.018 (0.013)	0.0040 (0.00082)
	114	0.018 (0.013)	5.6E-4 (4.3E-4)
117	117	0.010	0.003
	118	0.019	0.008
	119	0.0047	0.00087 (0.00044)

Conventional multi-wire losses = 6 – 7 \times Ti. Expect $W/Ti(X_0) = 6.7$

Beam position stability: \bar{p} kicker

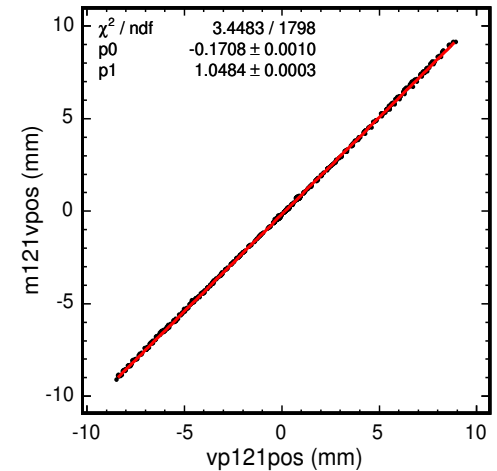
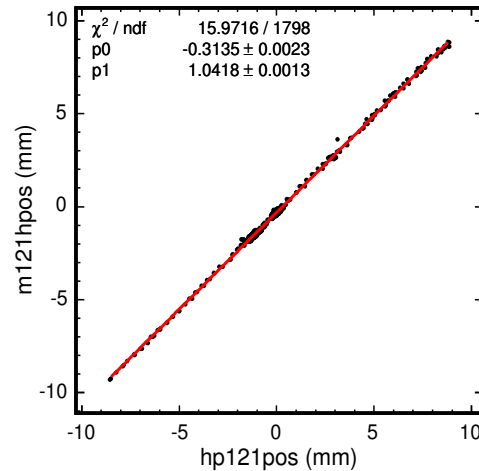
In mixed mode running, noise from the \bar{p} kicker magnet is picked up by the first proton batch, causing instability in the position of the beam on target. Largest variation is 1.5 mm in the horizontal.



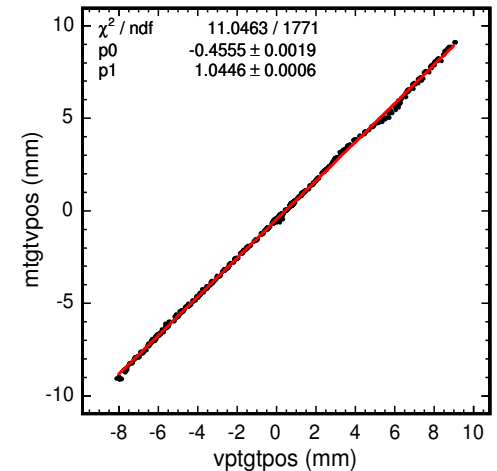
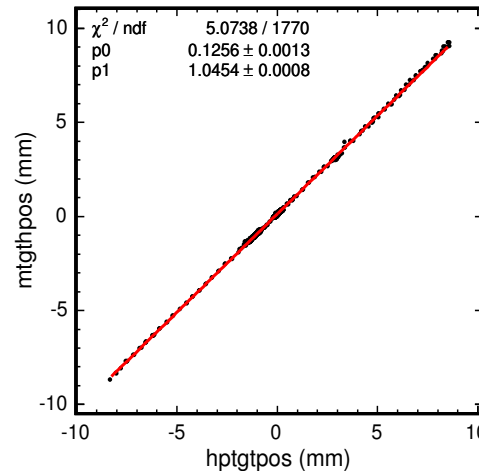
Beam position BPM vs PM

BPM measurements are used by NuMI autotune to stabilize and steer the beam.

- Corrections to raw BPM readout include alignment, mechanical centers, electrical centers and electronic corrections.

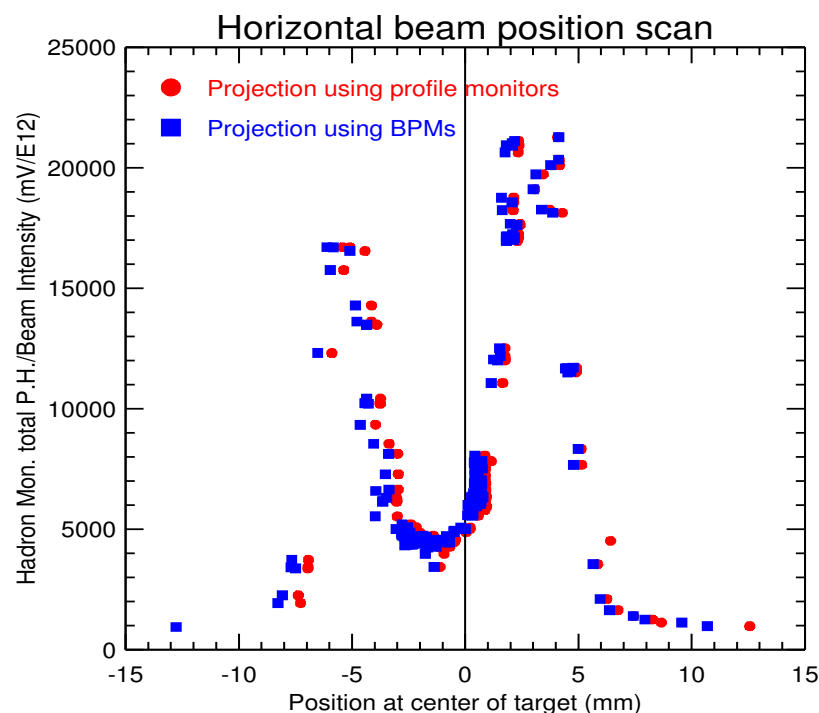
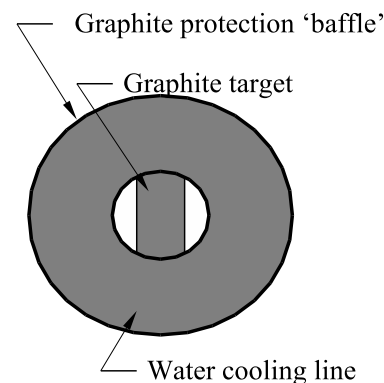


- Discrepancies between BPM and PM measurements of beam position in pretarget region as large as 0.5 mm.



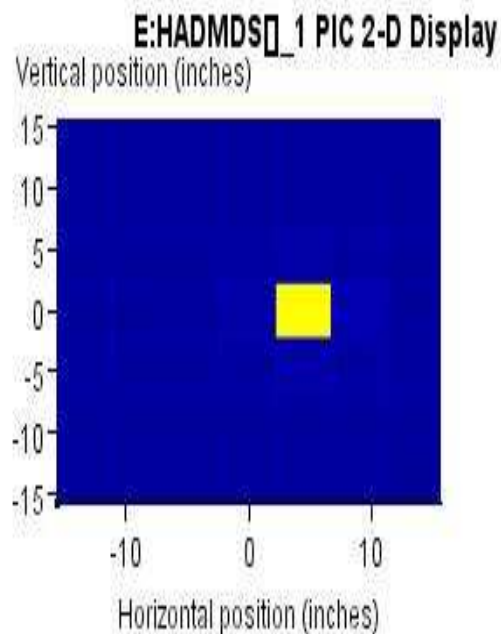
Beam position at target

- First target scan on Jan 21, 2005 using hadron and muon monitors.
- **BOTH BPM and PM** projections at the target indicated target is between -1 and -2 mm in the horizontal, +1mm in the vertical. See Bob's talk.
- We now aim the beam - 1.5mm in the horizontal and +1mm in the vertical.



Beam position at hadron absorber

Remove the target and do a beam scan with the hadron monitor.

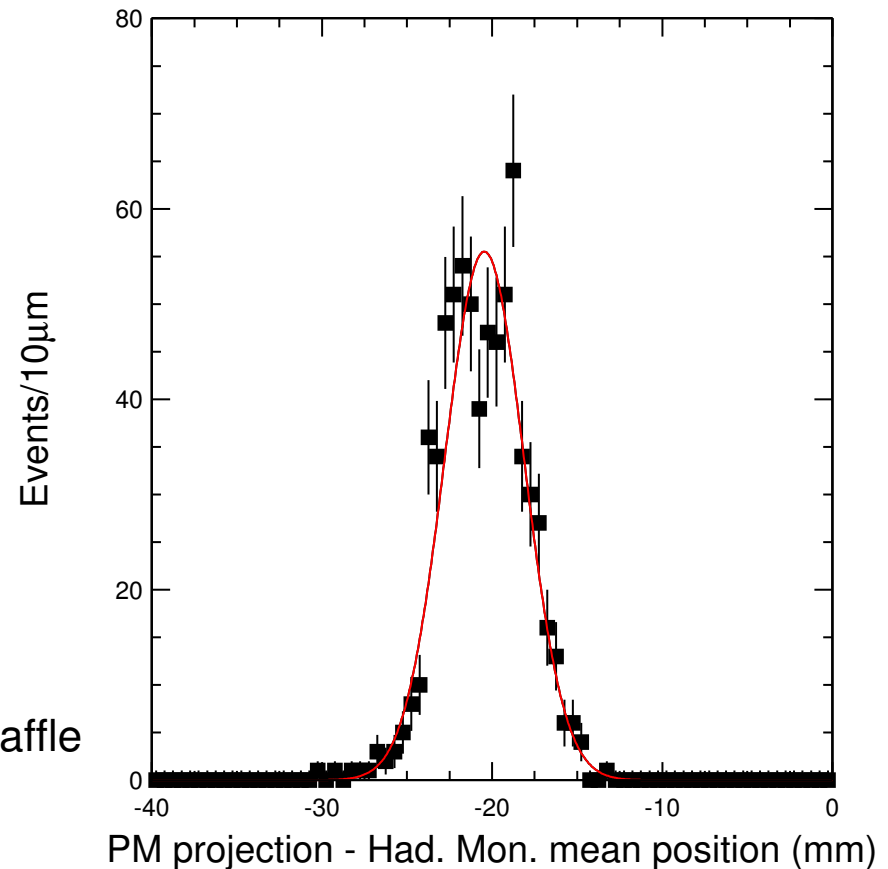


Entries :	49
XMean :	3.4743
XRms :	5.7998
YMean :	-0.19943
YRms :	5.2092
SumOfWeights :	265927

Hadron mon. display. Beam between target and baffle

MINUIT χ^2 Fit to Plot 100&0
Offset between PM and Had. Mon. (Horizontal)
File: *beamtuple.hbook
Plot Area Total/Fit 693.00 / 693.00
Func Area Total/Fit 650.75 / 650.75
 $\chi^2 = 45.4$ for 100 - 3 d.o.f.,
Errors Parabolic Minos
Function 1: Gaussian (sigma)
AREA 650.75 ± 25.58 - 25.58 + 25.58
MEAN -20.456 $\pm 9.3686\text{E-}02$ - 9.3805E-02 + 9.3717E-02
SIGMA 2.3383 $\pm 6.2257\text{E-}02$ - 6.2247E-02 + 6.2351E-02

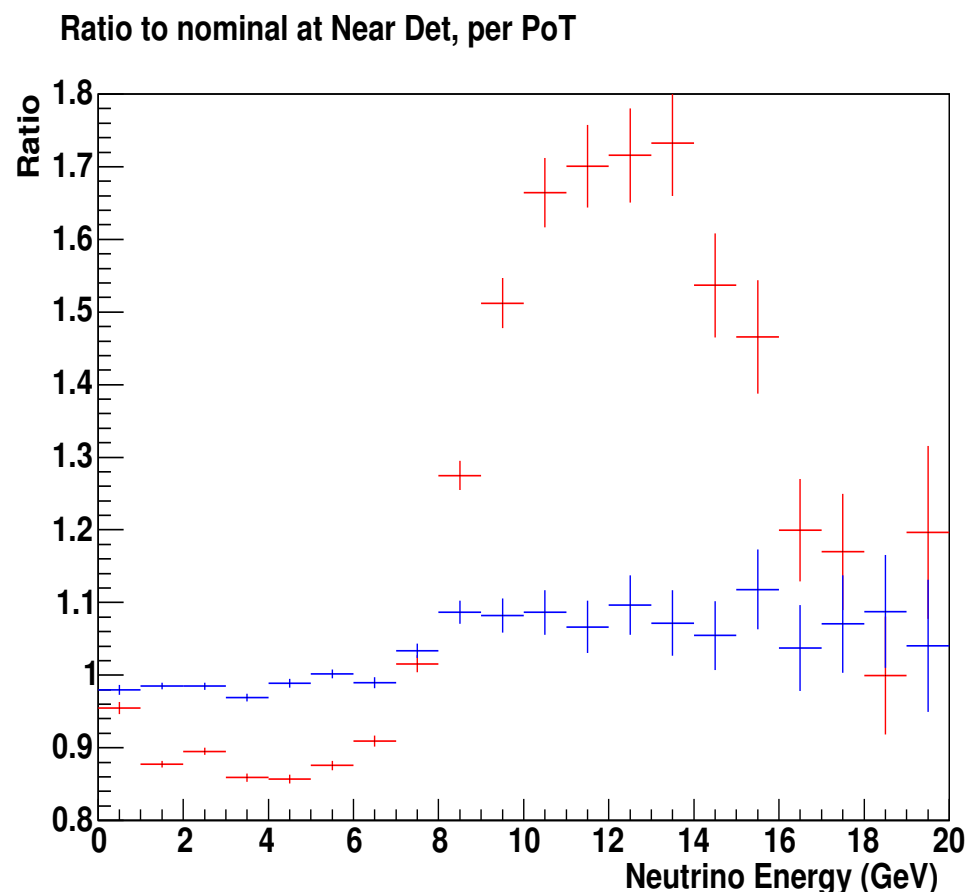
11-MAR-2005 17:05
Fit Status 3
E.D.M. 1.613E-08
C.L.=100.0%



Beam position stability: MC

MC simulations of pME beam generated to match beam conditions in runs 6067 (1.6mm off center) and 6068

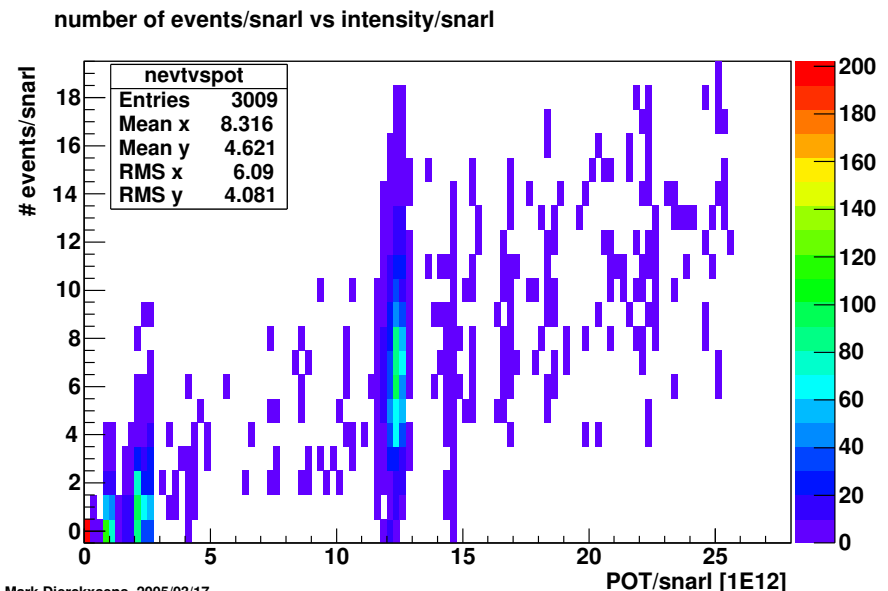
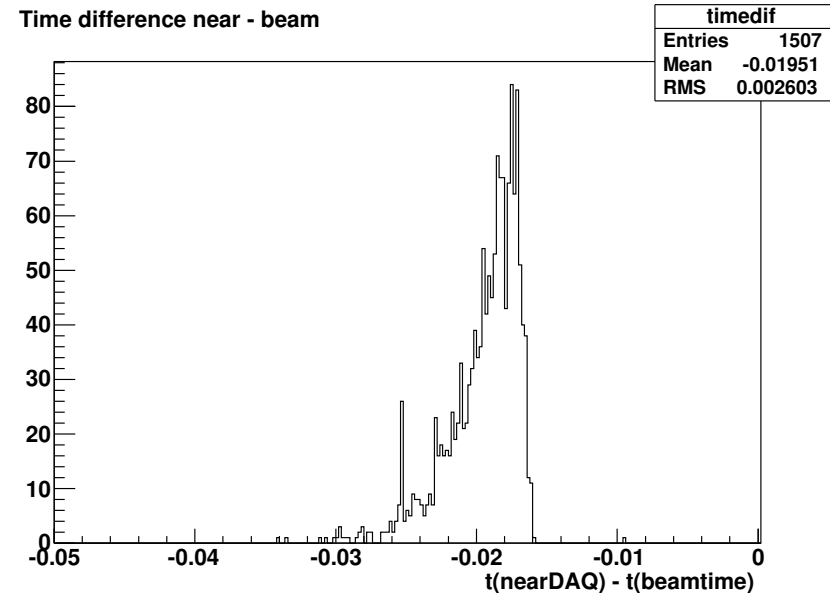
	Nominal	Run 6067	Run 6068
PoT	10e6	4e6	6e6
BeamX0	0	+1.72 mm	-0.59mm
BeamY0	0	+0.41mm	+0.41mm
BeamSigX	0.7mm	0.97mm	0.97mm
BeamSigY	1.4mm	1.15mm	1.22mm



MC studies indicate variations of 1.5 mm in beam position at the target produce significant variations in ν spectrum.

Correlating beam data with ND

- Using the VME front end timestamps from the profile monitor, hadron and muon, we can correlate beam data with ND spills.
- Initial measurements of ND event rate with pME beam vs POT/spill
- Need to build the formal software framework to correlate beam data with ND and FD (HELP!).



Mark Dierckxsens, 2005/03/17

Conclusions

- There is no magic formula for getting rid of beam position instability caused by the \bar{p} kicker in mixed mode running.
- Instabilities in beam width due to “bad booster” is also something we may have to live with.
- We still do not understand the beam optics. This is important for extrapolating the beam size to the target.
- What is the source of the discrepancy between the BPM and PM beam position measurements. ?
- Is the apparent displacement of the target region with pretarget a real alignment problem or an artifact of BPM calibrations?.

Thanks to all the MI and NuMI folk for the late hours and detailed studies.
